Galaxy Dynamics: from the Early Universe to the Present
ASP Conference Series, Vol. 3×10^8*, 1999*
F. Combes, G. A. Mamon and V. Charmandaris, eds.

Gas and stellar 2D kinematics in early-type galaxies

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Abstract. We have obtained integral field spectroscopy of a small sample of early-type galaxies to study the kinematical coupling between the stellar and gaseous components in their central regions.

1. Introduction

It is surprising to see how widely accepted is the assumption that giant early-type galaxies tend to have triaxial shapes (fainter ones being predominantly axisymmetric), when strong and convincing cases of triaxiality are rare (e.g. Merritt 1999 and references therein). Fits to the kinematics of luminous early type galaxies using axisymmetric models are surprisingly good, although this may be linked, in most cases (but see Statler, Dejonghe, & Smecker-Hane 1999), to a critical lack of detailed kinematical information. Thus a more accurate statement would be: we still do not know much about the detailed intrinsic shape and dynamics of early-type galaxies.

In this context, two-dimensional kinematical maps are a prerequisite for the determination of the underlying gravitational potential. Stars contribute for most of the visible mass of early-type galaxies and their motions are (almost exclusively) determined by gravitation. However, general axisymmetric and triaxial dynamical models are not easy to build, mainly because of the very large solution space to probe. Gas orbits are thought to be simpler to deal with (as generally assumed circular or elliptical), but non-gravitational motions can enter the play, particularly in the central regions. The realisation, not that long ago (see e.g. Goudfrooij 1997 and references therein), that most early-type galaxies do contain a significant gaseous component, led us to start a program to obtain the 2D kinematics of the stellar AND gaseous components in the central regions of a small sample of early-type galaxies.

2. Observations

We have observed about a dozen early-type galaxies using the `TIGER` Integral Field Spectrograph (IFS) at the CFH Telescope. The `TIGER` spectrograph provided about 400 spatial elements, homogeneously covering the field of view with a spatial sampling of $0\farcs39$.

To obtain both the stellar and gas kinematics, we observed two spectral domains, namely a `blue` domain around 5200Å, including the Mg triplet as well as Ca and Fe stellar absorption lines, and a `red` one including the Hα, [NII] and [SII] emission lines. The spectral sampling was 1.5Å per pixel, with a final resolution of 1700 and 2200 in the `blue` and `red`, respectively.

The data have been reduced using a dedicated software developed at the Lyon Observatory (Rousset, PhD Thesis, Lyon). The two major difficulties were: first to correct the `blue` spectra from the contamination by the [NI]λ5200 emission line (when present), and second to properly subtract the stellar contribution (mainly the Hα absorption line) from the `red` spectra. This was achieved with an algorithm which includes a library of stellar and galaxy spectra (coll. Paul Goudfrooij). Illustrative examples of the resulting subtractions are given in Fig. 1. Maps of the distribution and kinematics of the gas and stellar components were then built for all the galaxies in the sample, and will soon be published in a forthcoming paper through a collaboration with P. Goudfrooij (StSci) and P. Ferruit (Uni. of Maryland & CRA Lyon).

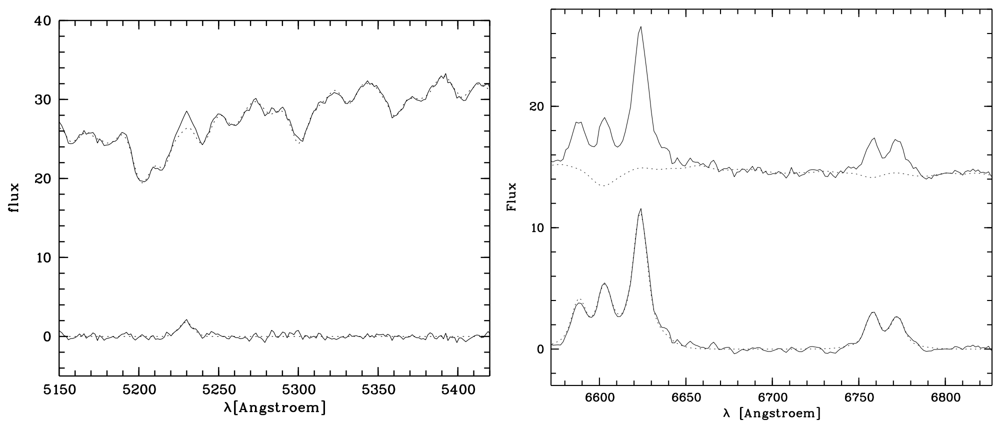

Figure 1. Example of stellar continuum subtraction for a `blue` (left) and `red` (right) spectra of NGC 2974. Top: original spectra (solid) and their best fit continuum spectra (dotted). Bottom: the continuum subtracted spectra (solid) and the emission line fits (dotted).

3. Results

The ionised gas distribution in these galaxies exhibit a variety of morphologies, including nuclear spirals (e.g. NGC 2974, NGC 4278), point-like emission regions (NGC 3414, NGC 6482), corotating disks (NGC 5838, NGC 2749) and counter-rotating discs (NGC 128). In some objects, part of the gas is clearly coupled

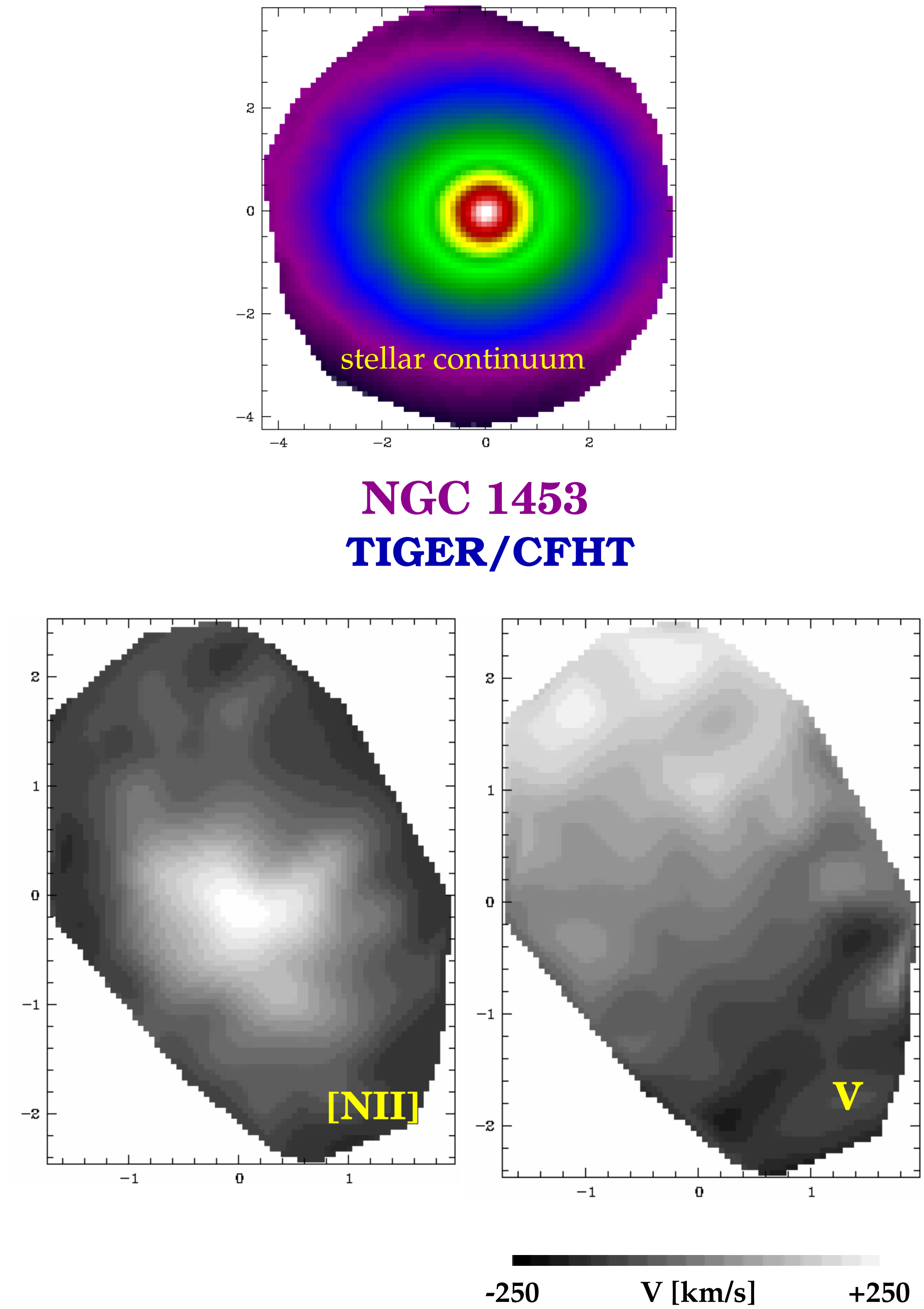

Figure 2. `TIGER` data of NGC 1453: stellar continuum (V band) reconstructed image (top), the ionised gas distribution map (bottom left, [NII]λ6584) and the corresponding gas velocity field (bottom right).

with the dust component (e.g. NGC 4374, see Bower et al. 1997), although this is not a systematic feature. In most cases, the gas and stars have different angular momentum axis. One striking example is NGC 1453, in which they are tilted by about 50 degrees with respect to each other (Fig. 2), suggesting a triaxial geometry (see also Pizzella et al. 1997).

The blended Hα/[NII] emission line system often exhibits broad wings which could be interpreted as resulting from the presence of a broad Hα line (a BLR). However, in all cases, these broad wings are also observed in the forbidden [SII] emission lines, although with a lower contrast. This argues for an unresolved kinematical gradient in the centre of these galaxies. This is confirmed by the spatial mapping of these wings, whose presence is limited to an unresolved central peak. The fact that these wings are weaker in the [SII] lines could be naturally explained by its lower critical density, which diminishes the contribution of high-density regions. This obviously does not mean that BLRs are not present, but set an upper limit on their contribution to the central emission line spectra.

All our spectra are compatible with the LINER type, although at different levels of activity. This is consistent with the compilation done by Ho, Fillipenko, & Sargent (1997) for the 7 objects in common. It is interesting to note that two of the four most active galaxies in our sample do show the presence of a nuclear spiral, the third one (M 87) having a spiral-like gas disc, and the fourth being viewed nearly edge-on. Central spiral structures may therefore play a role in the nuclear activity (see also Regan & Mulchaey 1999).

4. Perspectives

While our sample is not complete in any sense, it is striking to observe the morphological and kinematical decoupling of the ionised gas with respect to the stellar component. This certainly hints for an external origin in most cases. We plan to continue this study by using the recently comissioned integral field spectrograph OASIS, mounted on the adaptive optics bonnette of the CFHT. Our understanding of the gas/stars coupling in early-type galaxies will also greatly benefit from the on-going survey at the WHT conducted by the `SAURON` Consortium (Lyon/Leiden/Durham).

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